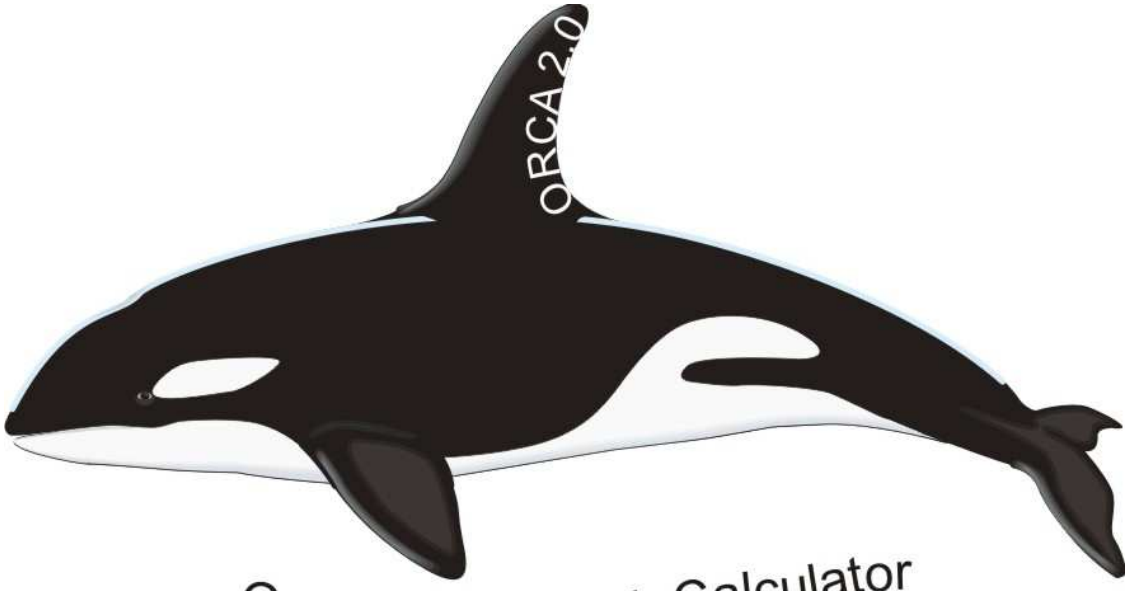

Occupational Risk Calculator

USER MANUAL

DOCUMENT CONTROL

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Revision history

Version	Change description	Prepared by	ORCA version	Issued
1.0	First version	RPS	0.8..17.212	03-2009
1.1		RPS	2.0	04-2009

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HOW TO READ THIS MANUAL

This manual can be used as a reference guide while working with the program itself or it can be read as an introductory or learning guide.

By use of a simple example the reader is taught how to use the software tool. The example is a small company that simply builds ‘walls’. To build these wall the company employs bricklayers, forklift drivers and inspectors. Whenever you see this bricklayer symbol, the example is discussed.

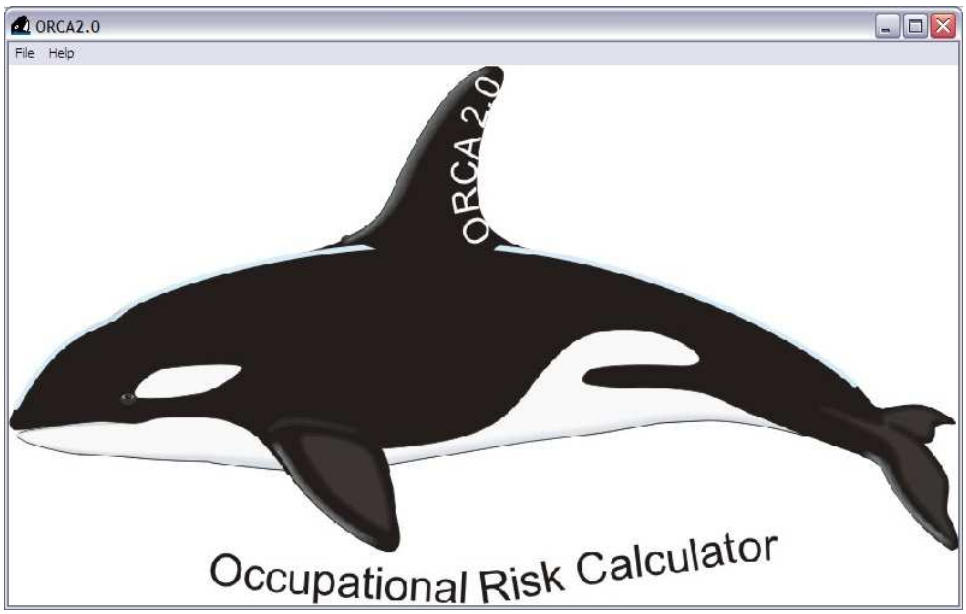
Most of the chapter titles refer to the tab-names in the ORCA tool. When the name a chapter refers to a tab it is shown between quotes (e.q. ‘Exposure’).

Reading tip: read the manual with the workflow diagram in mind

INSTALLING AND STARTING ORCA

The installation procedure for the ORCA tool is pretty straightforward and resembles most standard installation wizards. After installation has finished, the system does requires a reboot.

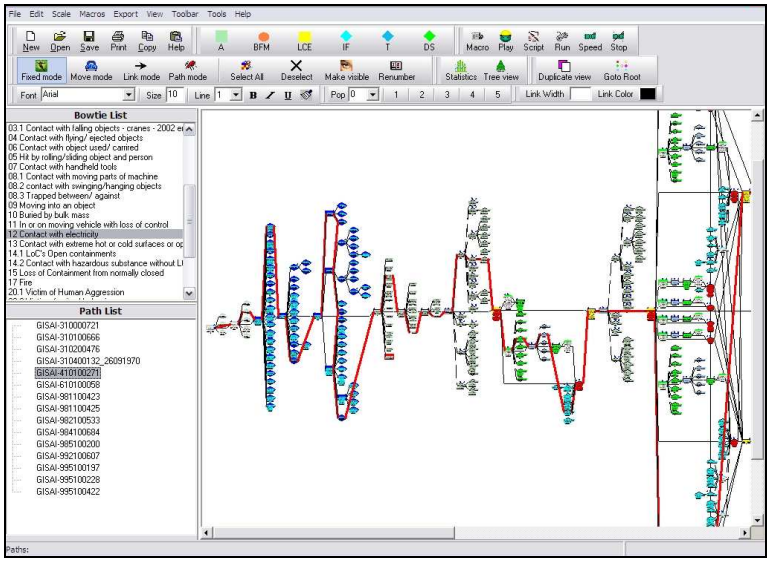
After double-clicking the ORCA icon, the tool will start without opening a file. The user is then able to start a new file or open a previously saved file. The file extension used by ORCA is MDB.



Screenshot 1 The ORCA tool opening screen.

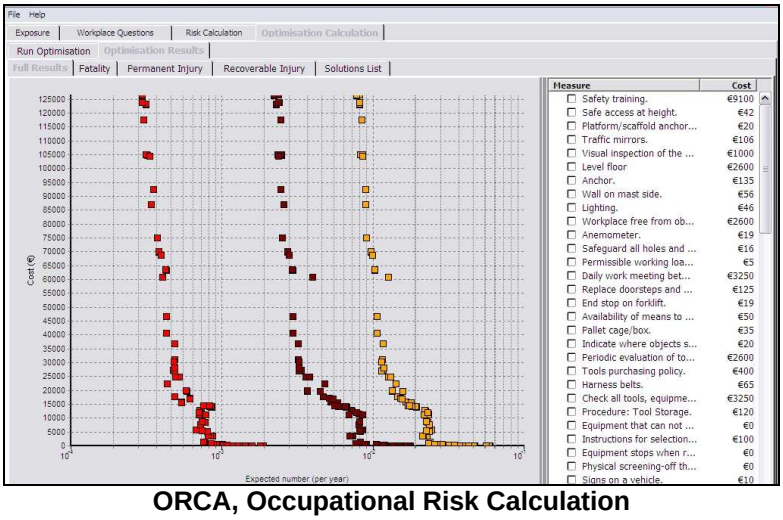
ABOUT ORCA

At the request of the Dutch Ministry of Social Affairs and Employment a model for the calculation of occupational risks has been developed. On a daily basis, workers face the risk of an accident resulting in a fatality, permanent or recoverable injury. These accidents were categorized into 36 scenario's for each of which a specific bow-tie model has been designed . With the software tool Storybuilder, over 12500 accidents reports made by the Dutch Labour Inspectorate have been analyzed and translated into paths or 'stories' through their appropriate bow-tie.



Paths through Storybuilder

Together with Storyfilter and a cost-measure database these efforts have resulted in what is now known as ORCA. The goal of ORCA is to create a company specific risk profile. This profile consists of company risks and individual risks for different job positions. This risk profile also incorporates the actual situation within the company by asking questions about the state of safety barriers. Based on this profile, ORCA is able to present solutions (and their cost) for improving safety. Thereby facilitating an optimal balance between safety and budget.



ORCA, Occupational Risk Calculation

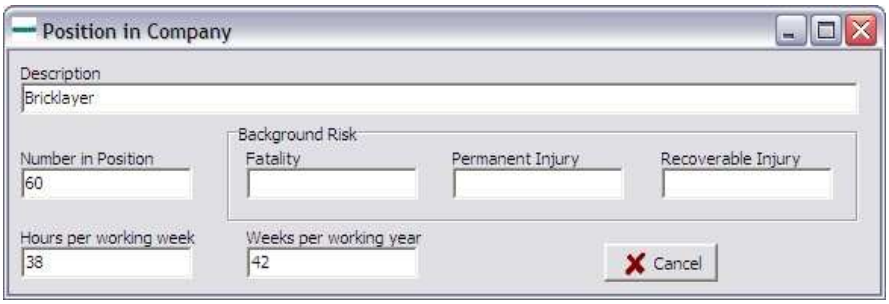
1. ‘EXPOSURE’

Most people who work for a company are exposed to at least one but often several hazards. Each person (or each job position) is also exposed to different hazards for different durations. In ORCA, the first step is to define what job positions in your company you wish include in the process. For each job position you need to define how often these job positions are exposed to different hazards.

‘Position in company’

After you have created a new file, ORCA will immediately present you with a first dialogue box to start off your analysis. This dialogue box asks you to describe a ´Position in Company´. This is simply any job position that is relevant to your analysis. The user can choose between specifiying a ‘position in company’ for each individual (and their unique characteristics) or for a group of people, all performing the same job.

In our example (a small company that constructs walls and employs bricklayers, forklift drivers and inspectors), we have entered the position of ´bricklayer´, thereby specifying an entire group of people and not individuals. Important additional information, which has to be entered on this type of position, is the ´Number in Position´ (in our case there are 60 bricklayers in the company), also the ‘Hours per working week’ and ‘Weeks per working year’ should be entered. In this case bricklayers work for 38 hours every week and 42 weeks in every year.



Screenshot 2 'Position in Company'

Additionally it is possible to incorporate a ´background risk´ into all of the risk calculations. For example, when a bricklayer is working to construct a wall on the premises of a large petrochemical plant this will constitute a background risk, additional to the risk the bricklayer faces because of his construction work.

The example in this manual uses two more positions, that of a forklift driver and an inspector. The table below shows all information for these job positions. To add, edit or delete job positions there are corresponding buttons available in the bottom part of the ORCA tool.

Position in Company	Number in position	Background risk of fatality per year	Background risk of permanent injury per year	Background risk of recoverable injury per year	Hours per working week	Weeks per working year
Bricklayer	60				38	42
Forkliftdriver	15				38	42
Inspector	3				38	42

Add Edit Delete

Screenshot 3 Positions in Company in this example

'Exposure for position'

After clicking on the tab 'exposure for position', the first choice which has to be made is on the method you wish to for identifying the hazards for each job position. The choice is between '**hazard list**' and '**activity list**'.The most commonly used method is the 'hazard list'. For each new job position this choice has to be made.

If, for some reason, you wish to change to the 'activity list' method, clicking on the 'redefine job' button **will clear all hazards** and present you with the initial choice between the two methods.

Screenshot 4 Choosing a method for identifying hazards

The 'hazard list' method

The process of choosing a hazard is relatively easy, just check the hazard(s) of your choice in the checkbox. Added to the hazard list is the 'working context'. This is merely a description to help choose the appropriated hazard.

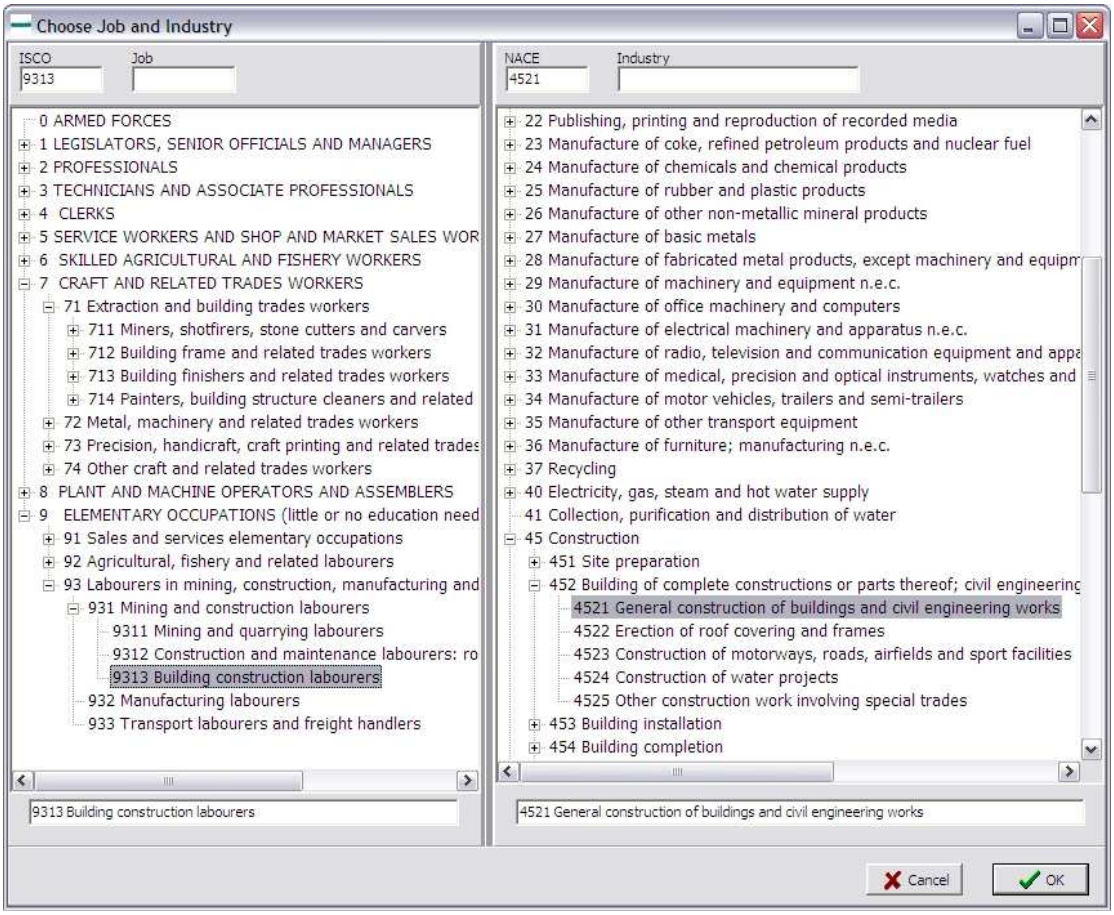
Working context	Hazard list
☐ Climbing or working on a placement ladder	Fall from height - Placement ladder
☐ Climbing or working on a fixed ladder	Fall from height - Fixed ladder
☐ Climbing or working on a step ladder or steps	Fall from height - Step ladder or steps
☐ Climbing or working on a rope ladder	Fall from height - Rope ladder
☐ Working on a mobile scaffold	Fall from height - Working on mobile scaffold
☐ Working on a fixed scaffold	Fall from height - Working on fixed scaffold
☐ Working on a scaffold, while (de-)installing	Fall from height - (de-)installing Scaffold
☐ Working on a roof	Fall from height - Roof
☐ Working on a floor or balcony	Fall from height - Floor
☐ Working on a fixed platform	Fall from height - Fixed Platform
☐ Working near hole in ground	Fall from height - Hole in ground
☐ Working on a moveable platform	Fall from height - Moveable platform
☐ Working on a non-moving vehicle	Fall from height - Non-moving vehicle
☐ Working on other objects, constructions etc, unprotected	Fall from height - Other
☐ Walking or standing	Fall on same level
☐ Walking on stairs or ramp	Fall down stairs or ramp
☐ Working or walking near moving vehicles	Struck by moving Vehicle

Screenshot 5 The hazard list & working context

The ‘activity list’ method

This method is a more guided process for selecting appropriate hazards. Although in our example we will select hazards manually (with the ‘hazard list’ method) the ‘activity list’ method also explained in this section. The job position of ‘bricklayer’ is used as an example.

The first step is to add an ‘job:industry’ pair for the bricklayer. For this purpose a classification for jobs and industries (ISCO and NACE) is used. After clicking on the ‘add job:industry’ button you are presented with this list of jobs and industries. For each ‘position’ (in our case a bricklayer’) a job:industry combination has to be chosen. Here we have chosen for the job of ‘Building construction labourers’ in the ‘general construction’ industry.


Choose Job and Industry
ISCO
9313
Job
0 ARMED FORCES
1 LEGISLATORS, SENIOR OFFICIALS AND MANAGERS
2 PROFESSIONALS
3 TECHNICIANS AND ASSOCIATE PROFESSIONALS
4 CLERKS
5 SERVICE WORKERS AND SHOP AND MARKET SALES WOR
6 SKILLED AGRICULTURAL AND FISHERY WORKERS
7 CRAFT AND RELATED TRADES WORKERS
71 Extraction and building trades workers
711 Miners, shotfirers, stone cutters and carvers
712 Building frame and related trades workers
713 Building finishers and related trades workers
714 Painters, building structure cleaners and related
72 Metal, machinery and related trades workers
73 Precision, handicraft, craft printing and related trades
74 Other craft and related trades workers
8 PLANT AND MACHINE OPERATORS AND ASSEMBLERS
9 ELEMENTARY OCCUPATIONS (little or no education need
91 Sales and services elementary occupations
92 Agricultural, fishery and related labourers
93 Labourers in mining, construction, manufacturing and
931 Mining and construction labourers
9311 Mining and quarrying labourers
9312 Construction and maintenance labourers: ro
9313 Building construction labourers
932 Manufacturing labourers
933 Transport labourers and freight handlers
9313 Building construction labourers
NACE
4521
Industry
22 Publishing, printing and reproduction of recorded media
23 Manufacture of coke, refined petroleum products and nuclear fuel
24 Manufacture of chemicals and chemical products
25 Manufacture of rubber and plastic products
26 Manufacture of other non-metallic mineral products
27 Manufacture of basic metals
28 Manufacture of fabricated metal products, except machinery and equipm
29 Manufacture of machinery and equipment n.e.c.
30 Manufacture of office machinery and computers
31 Manufacture of electrical machinery and apparatus n.e.c.
32 Manufacture of radio, television and communication equipment and appa
33 Manufacture of medical, precision and optical instruments, watches and
34 Manufacture of motor vehicles, trailers and semi-trailers
35 Manufacture of other transport equipment
36 Manufacture of furniture; manufacturing n.e.c.
37 Recycling
40 Electricity, gas, steam and hot water supply
41 Collection, purification and distribution of water
45 Construction
451 Site preparation
452 Building of complete constructions or parts thereof; civil engineering
4521 General construction of buildings and civil engineering works
4522 Erection of roof covering and frames
4523 Construction of motorways, roads, airfields and sport facilities
4524 Construction of water projects
4525 Other construction work involving special trades
453 Building installation
454 Building completion
4521 General construction of buildings and civil engineering works
Cancel
OK

Screenshot 6 Choosing a ‘job:industry’ pair

After having chosen the appropriate job:industry pair for a job position, the next step is to identify one or more hazards, ORCA helps you to identify activities and their associated hazards. The activity list method has two ways to do this, the ‘advisory activity list’ and the ‘full activity list’.

Screenshot 7 Adding activities and their related hazards using the 'activity list' method

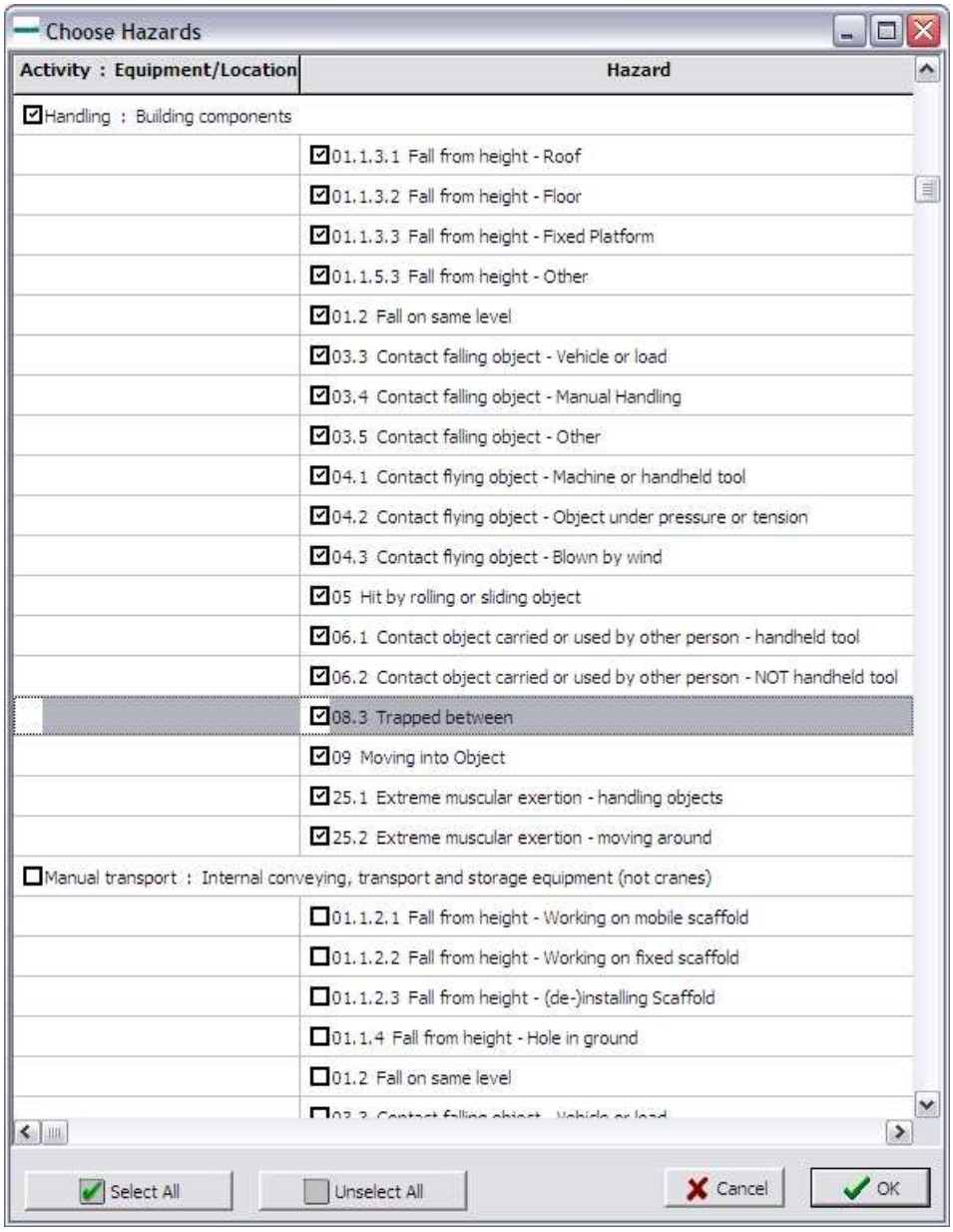
Advisory activity list

Since activities and hazards are closely associated, ORCA can show you an **'Advisory activity list'**. You, the user, must then select 'activity:equipment/location' pairs.

For example:

Job:Industry	=	Building construction labourers : General construction
Activity:Equipment/location	=	Handling : building components
Hazard	=	Trapped between

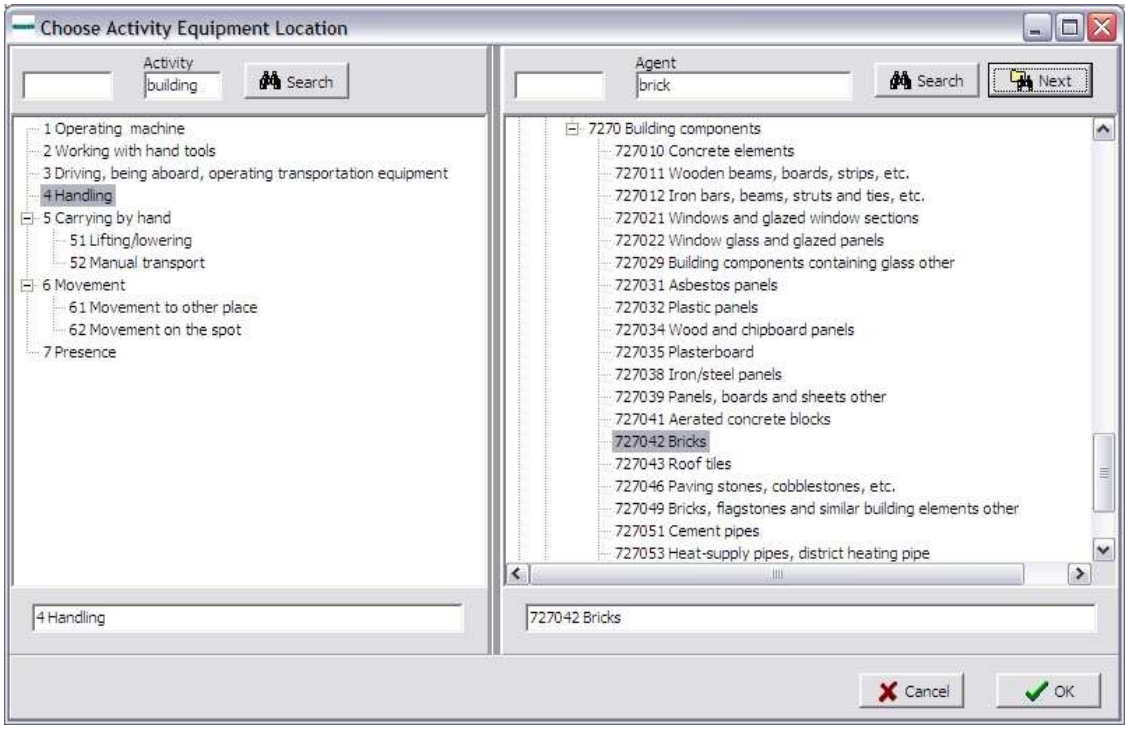
The screenshot below shows the advised Activity:Equipment/location pairs for an industry and the associated hazards. It is up to the user to select one, several or all hazards for a Activity:Equipment/location pair.


Choose Hazards
Activity : Equipment/Location
Hazard
Handling : Building components
01.1.3.1 Fall from height - Roof
01.1.3.2 Fall from height - Floor
01.1.3.3 Fall from height - Fixed Platform
01.1.5.3 Fall from height - Other
01.2 Fall on same level
03.3 Contact falling object - Vehicle or load
03.4 Contact falling object - Manual Handling
03.5 Contact falling object - Other
04.1 Contact flying object - Machine or handheld tool
04.2 Contact flying object - Object under pressure or tension
04.3 Contact flying object - Blown by wind
05 Hit by rolling or sliding object
06.1 Contact object carried or used by other person - handheld tool
06.2 Contact object carried or used by other person - NOT handheld tool
08.3 Trapped between
09 Moving into Object
25.1 Extreme muscular exertion - handling objects
25.2 Extreme muscular exertion - moving around
Manual transport : Internal conveying, transport and storage equipment (not cranes)
01.1.2.1 Fall from height - Working on mobile scaffold
01.1.2.2 Fall from height - Working on fixed scaffold
01.1.2.3 Fall from height - (de-)installing Scaffold
01.1.4 Fall from height - Hole in ground
01.2 Fall on same level
Select All
Unselect All
Cancel
OK

Screenshot 8 Using the ´advisory activity list` to choose hazards based on these activities.

Full activity list

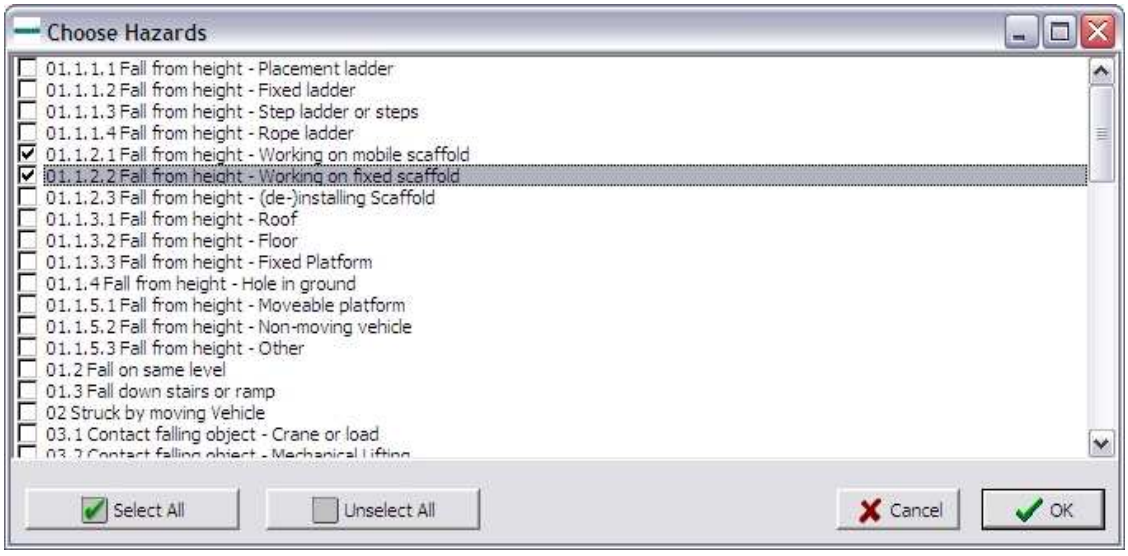
It's also possible to select hazards using the **'Full activity list'**. Here, ORCA will not advise you but instead lets you choose hazards from the entire list. After clicking on the ´Full activity list´ button (Screenshot 7) ORCA will again show you a dialogue box called 'Choose Activity Equipment Location' which lets you choose an activity and agent.



Screenshot 9 The 'full activity list' method : picking an activity and agent

You are then presented with a second dialogue box: a full list of potential hazards. Obviously, clicking on a checkbox will select a hazard. It is possible to select more than one hazard.

Please note: selected hazards are (again) only for the specified job position.


Choose Hazards
01.1.1.1 Fall from height - Placement ladder
01.1.1.2 Fall from height - Fixed ladder
01.1.1.3 Fall from height - Step ladder or steps
01.1.1.4 Fall from height - Rope ladder
01.1.2.1 Fall from height - Working on mobile scaffold
01.1.2.2 Fall from height - Working on fixed scaffold
01.1.2.3 Fall from height - (de-)installing Scaffold
01.1.3.1 Fall from height - Roof
01.1.3.2 Fall from height - Floor
01.1.3.3 Fall from height - Fixed Platform
01.1.4 Fall from height - Hole in ground
01.1.5.1 Fall from height - Moveable platform
01.1.5.2 Fall from height - Non-moving vehicle
01.1.5.3 Fall from height - Other
01.2 Fall on same level
01.3 Fall down stairs or ramp
02 Struck by moving Vehicle
03.1 Contact falling object - Crane or load
Select All
Unselect All
Cancel
OK

Screenshot 10 The 'full activity list' method : choosing hazards for the job position

Choosing the appropriate hazards is an important step in the analysis. Besides performing a desk study, talking with people who actually do the work is often very helpful. They are usually well aware of the hazards they face on a daily basis. They may also be able to provide information on the time they are exposed to these hazards.

For our example, we have chosen several hazards for the bricklayer, forklift driver and inspector. These hazards do not necessarily represent a real-world company, they are meant for illustration purposes only. The chosen hazards are:

Example hazards for the position of ´bricklayer´:

- Fall from height - Working on fixed scaffold
- Fall on same level
- Contact falling object - Manual Handling
- Contact handheld tool by self

Example hazards for the position of forklift driver:

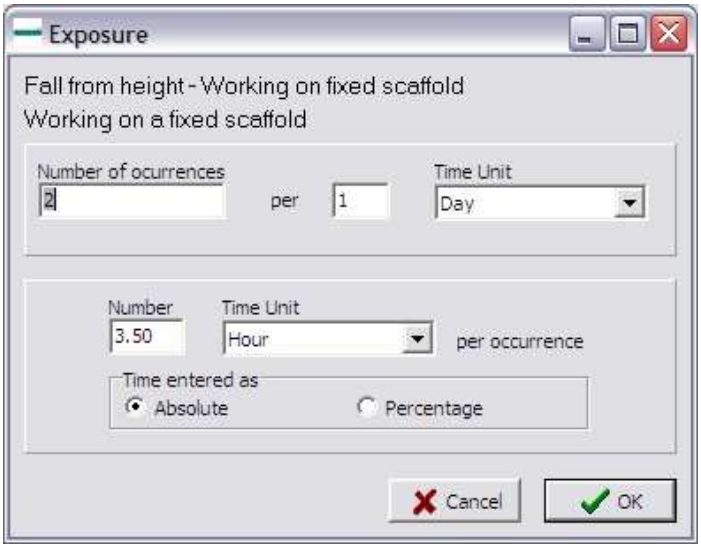
- Contact falling object - Mechanical lifting
- In or on moving vehicle with loss of control

Example hazards for the position of inspector:

- Fall from height - Working on fixed scaffold
- Fall on same level
- Contact falling object – Other

Exposure for hazards

When we know what hazards a specific job position is exposed to, it is important to know how often and for how long someone is exposed to this hazard. By picking a hazard and clicking on the 'edit exposure' button this information can be put into a dialogue box as shown below.



Screenshot 11 Exposure for a hazard

The exposure dialogue box is divided into two sections: This first section is used to enter *how often* someone in a job position is exposed to the hazard, that is the 'Number of occurrences' per 'Time unit'. Additionally, information on *how long* someone is exposed each time can be entered in the second section. Here we have used 3.5 hours per occurrence. An 'occurrence' is every moment a hazard is encountered, whether for a minute or several hours.

In our example company we have used these ‘exposure for hazards’:

Bricklayer

“After climbing the scaffolds in the morning, our bricklayers work on scaffolds for 3,5 hours. Around noon they go down for a lunch break of about half an hour and then resume work for another 3,5 hours. Traveling time up and down the scaffolding takes 15 minutes. Each morning and afternoon a 15 minute break on the scaffolding is taken”

Working context	:	Working on fixed scaffold
Hazard	:	Fall from height
Exposure	:	2 times per day, 3,5 hours each time.
Working context	:	Walking or standing
Hazard	:	Fall on same level
Exposure	:	4 times per day, 15 minutes each time.
Working context	:	(Being near) manual handling or transport of loads
Hazard	:	Contact falling object
Exposure	:	2 times per day, 3,25 hours each time.
Working context	:	Working with handheld tool
Hazard	:	Contact handheld tool by self
Exposure	:	2 times per day, 3,25 hours each time.

Forklift driver

“Our forklift drivers bring bricks to the scaffolding 16 times a day. Lifting the bricks onto the scaffolding takes 10 minutes and driving to and from the scaffolding is a 10 minute trip.”

Working context	:	Working with or being near mechanical lifting devices
Hazard	:	Contact falling object - Mechanical lifting
Exposure	:	16 times per day for 10 minutes each time
Working context	:	Working in or on moving vehicles
Hazard	:	In or on moving vehicle with loss of control
Exposure	:	32 times per day for 10 minutes each time

Inspector

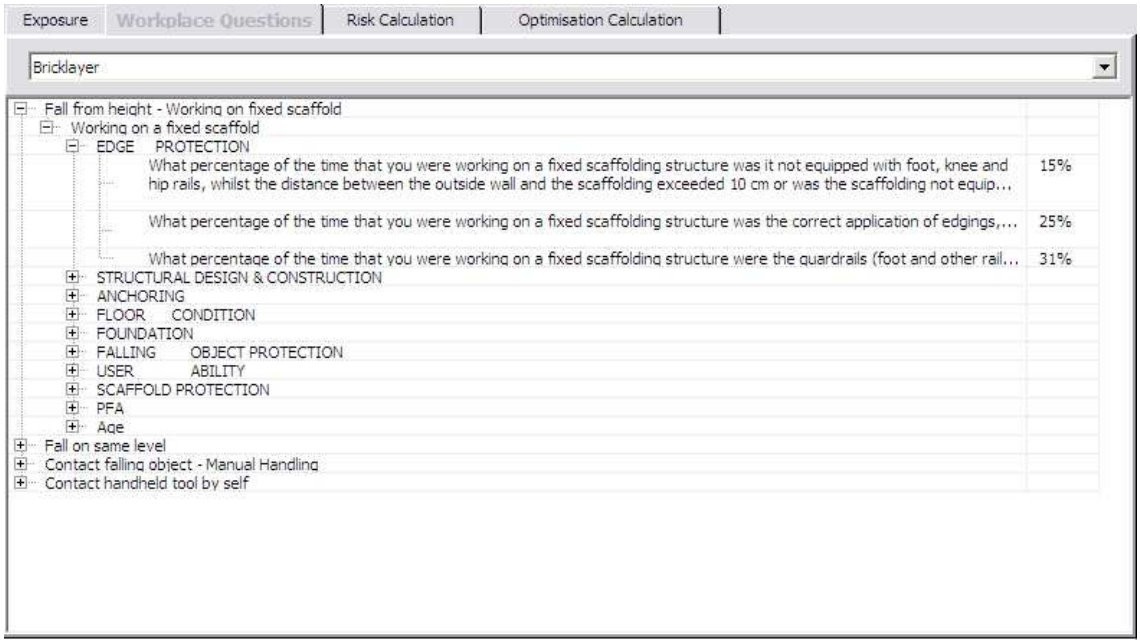
“The inspectors of the company inspect 4 sites each day on construction and work methods. An entire inspection takes about 1,5 hour. Going to and from these inspections takes 8 trips that last 15 minutes each. During these inspections bricks are delivered by the forklift driver on an average of 12 times a day”

Working context	:	Working on fixed scaffold
Hazard	:	Fall from height
Exposure	:	4 times per day for 1 hour each time
Working context	:	Walking or standing
Hazard	:	Fall on same level
Exposure	:	8 times per day for 15 minutes each time
Working context	:	(Being near) manual handling or transport of loads
Hazard	:	Contact falling object
Exposure	:	12 times per day, 10 minutes each time

2. ‘WORKPLACE QUESTIONS’

The next step in our analysis for improving company safety is answering the so called ‘workplace questions’. The model assumes that an accident is influenced by the unique situation of every individual company. That is, the workplace of every company is different and this fact needs to be taken into account in the analysis.

Workplace questions are often referred to as PIE-questions. The abbreviation PIE is for Probability Influencing Entity. This may be a difficult concept to grasp but using our example company it will become clear. For our bricklayers three workplace questions (or PIE’s) are shown. These questions are related to ‘barriers’.


Exposure
Workplace Questions
Risk Calculation
Optimisation Calculation
Bricklayer
Fall from height - Working on fixed scaffold
Working on a fixed scaffold
EDGE PROTECTION
What percentage of the time that you were working on a fixed scaffolding structure was it not equipped with foot, knee and hip rails, whilst the distance between the outside wall and the scaffolding exceeded 10 cm or was the scaffolding not equip...
15%
What percentage of the time that you were working on a fixed scaffolding structure was the correct application of edgings,...
25%
What percentage of the time that you were working on a fixed scaffolding structure were the guardrails (foot and other rail...
31%
STRUCTURAL DESIGN & CONSTRUCTION
ANCHORING
FLOOR CONDITION
FOUNDATION
FALLING OBJECT PROTECTION
USER ABILITY
SCAFFOLD PROTECTION
PFA
Age
Fall on same level
Contact falling object - Manual Handling
Contact handheld tool by self

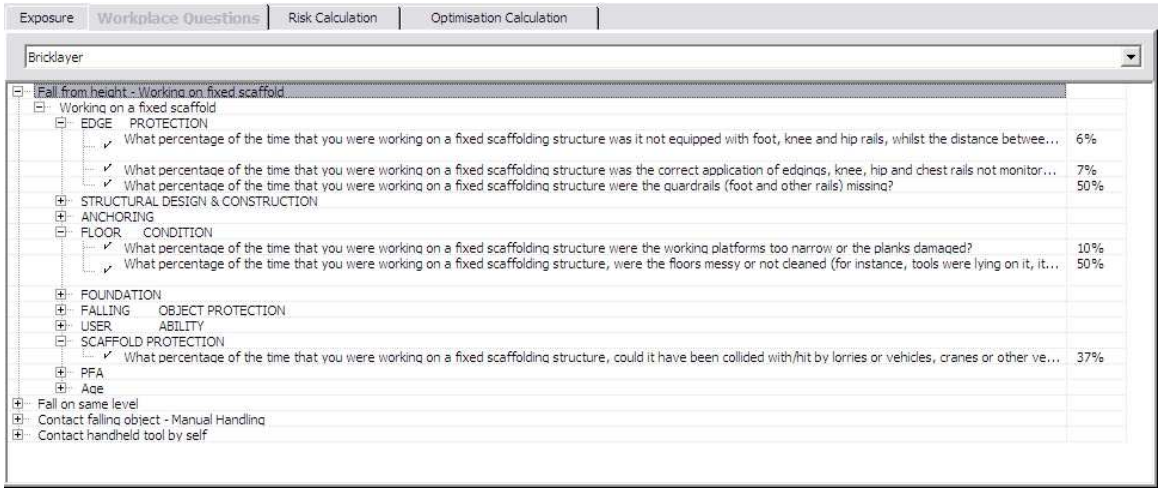
Screenshot 12 Workplace questions or PIE's

Hazards are present within a **working context** within which there are **barriers** in a state defined by the answers to the **workplace questions**. For example:

Hazard	:	Fall from height - Working on fixed scaffold
Working context	:	Working on fixed scaffold
Barrier	:	EDGE PROTECTION
Workplace question	:	“What percentage of the time that you….”

As you can see, there are three workplace questions (or PIE’s) for the barrier ‘EDGE PROTECTION”. This means that the answers to these questions (i.e. 15%, 25% and 31%) determine the chance that this barrier is in a ‘good’ state. Together, all barriers (in their respective states) determine the risk that a hazard poses.

In our example we have changed the answer to some questions. The answers to these workplace- or PIE questions are chosen at random serve to show differences, in later steps of the analysis, between the DNA (later more on this) and a company that is not ‘average’. These changes have been made:


Exposure
Workplace Questions
Risk Calculation
Optimisation Calculation
Bricklayer
Fall from height - Working on fixed scaffold
Working on a fixed scaffold
EDGE PROTECTION
What percentage of the time that you were working on a fixed scaffolding structure was it not equipped with foot, knee and hip rails, whilst the distance betwee... 6%
What percentage of the time that you were working on a fixed scaffolding structure was the correct application of edgings, knee, hip and chest rails not monitor... 7%
What percentage of the time that you were working on a fixed scaffolding structure were the guardrails (foot and other rails) missing? 50%
STRUCTURAL DESIGN & CONSTRUCTION
ANCHORING
FLOOR CONDITION
What percentage of the time that you were working on a fixed scaffolding structure were the working platforms too narrow or the planks damaged? 10%
What percentage of the time that you were working on a fixed scaffolding structure, were the floors messy or not cleaned (for instance, tools were lying on it, it... 50%
FOUNDATION
FALLING OBJECT PROTECTION
USER ABILITY
SCAFFOLD PROTECTION
What percentage of the time that you were working on a fixed scaffolding structure, could it have been collided with/hit by lorries or vehicles, cranes or other ve... 37%
PFA
Age
Fall on same level
Contact falling object - Manual Handling
Contact handheld tool by self

Screenshot 13 Workplace questions

A word on how the workplace question are phrased is in place: workplace questions are posed in ‘negative’ way. Mostly, they ask for a percentage of time that some form of safety equipment is not present. For example ”what percentage of time did you not wear your safety goggles?“ or “What percentage of the time that you were working on a fixed scaffolding structure were the guardrails missing?”. This means that lower answers are considered to be ‘better’.

The Dutch National Average, or DNA

To help answer these (often many) PIE questions with relative ease, ORCA answers them with the Dutch National Average, or DNA. From a population of 52.000 a random sample of 30.000 people from different industries were picked. These people were asked the workplace questions and their answers make up the Dutch National Average to these answers.

This default answer has two advantages. First, the user may accept all answers and then quickly continue with the next step and second, if the answers are adjusted for the typical company workplace circumstances, a comparison with the DNA can be easily made. **To adjust the default answer to the PIE questtions, just double-click on the answer (percentage) to show this dialogue box**:

PIE Question
Bricklayer
Fall from height - Working on fixed scaffold
Working on a fixed scaffold
EDGE PROTECTION
What percentage of the time that you were working on a fixed scaffolding structure was it not equipped with foot, knee and hip rails, whilst the distance between the outside wall and the scaffolding exceeded 10 cm or was the scaffol...
Dutch national average
15
Answer
15
Restore DNA
Cancel
OK

Screenshot 14 Answering a typical workplace or 'PIE' question

Whenever you change your answer, the color of the slide bar will change, depending on whether your answer is ‘better’ or ‘worse’ than the DNA with green being better than red.

3.´RISK CALCULATION´

In this step ORCA calculates the risk to the entire company, to (groups of) job positions, the risks to individuals and to so called 'missions'. We will start off with the risk to the company.

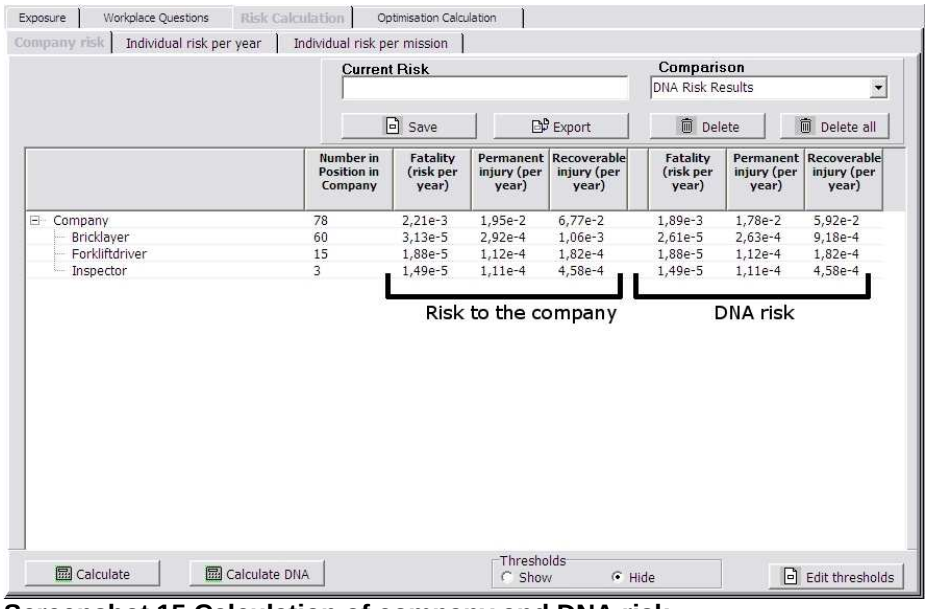
'Company risk (per year)'

The risk calculation step does not need any new information for the user. In the first tab called ´company risk´ the user can instruct ORCA to calculate the risks for his or her company and, for comparison purposes, ask ORCA to calculate the Dutch national average. A simple click on the ´calculate´ button will show the risks to the company, clicking on ´calculate DNA´ will result in the risk to an average Dutch company, *comparable to our example company*.

The information is shown in several rows and columns. In the rows we recognize the three job positions we have entered in the previous steps and the corresponding amount of job positions.

For both the company risk and the DNA risk, ORCA shows three different risk types. That of the risk for a fatal injury, for permanent injury and for recoverable injury. All risks are shown per year. In our example we can see that the risk for permanent injury for a bricklayer ($2{,}92 \cdot 10^{-4}$) is almost three times higher than the risk for an inspector ($1{,}11 \cdot 10^{-4}$). Comparing the risk to permanent injury that a bricklayer in our example company faces ($2{,}92 \cdot 10^{-4}$) with that of a bricklayer in an 'average' company ($2{,}63 \cdot 10^{-4}$) we see that working in our company is slightly more risky. This difference can be explained by the answers to the PIE questions as shown in Screenshot 13. Here some questions were scored lower than the DNA resulting in a higher risk to the bricklayer.

Since no changes were made to the PIE questions for the forkliftdriver or inspector, these risks remain the same as for the DNA.



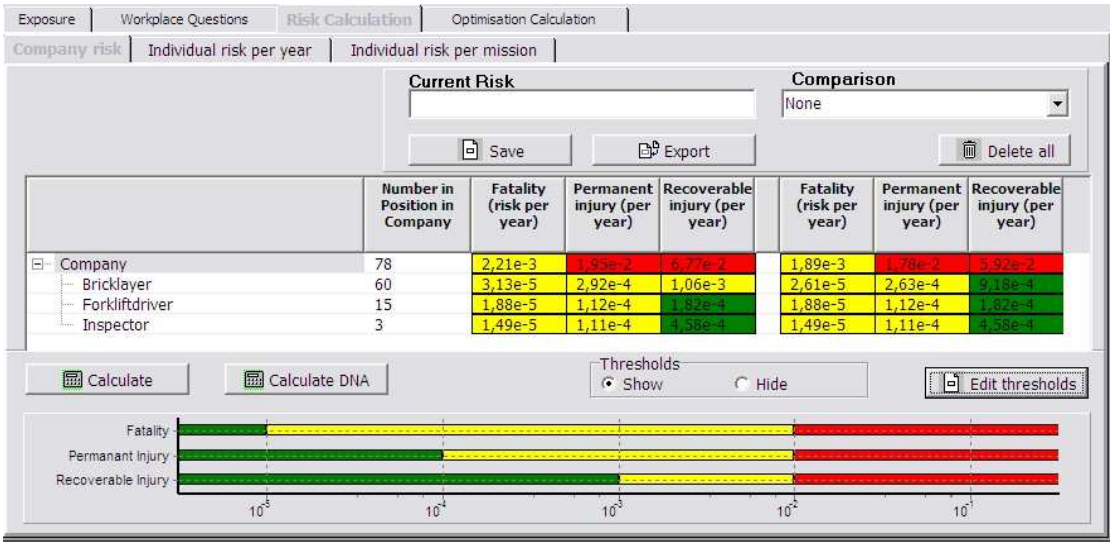
Screenshot 15 Calculation of company and DNA risk

Thresholds

ORCA lets the user enter 'thresholds' for the three types of injury. In ORCA, thresholds are only used for coloring (green, yellow or red) risks, thereby improving the readability of the table. They offer no other specific function in the application.

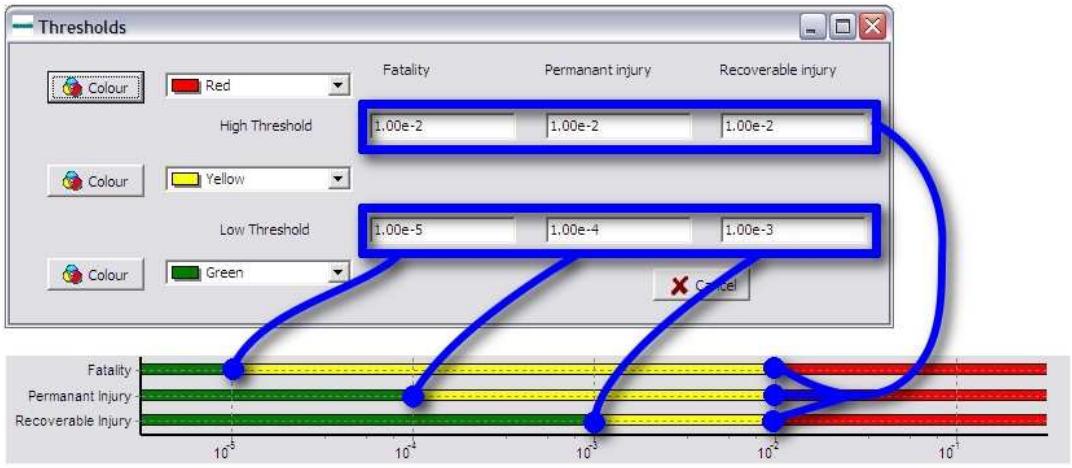
Switching between a presentation with or without the threshold is easily controlled with the radio button on the bottom of the screen. Although this feature is available in all of the three tabs of the risk calculation phase, they will not be used in the remaining part of this manual.

Our example only has three job positions but most companies have many more thus making this a very useful addition to the software. Screenshot 16 is a nice example.



Screenshot 16 Company risks and thresholds

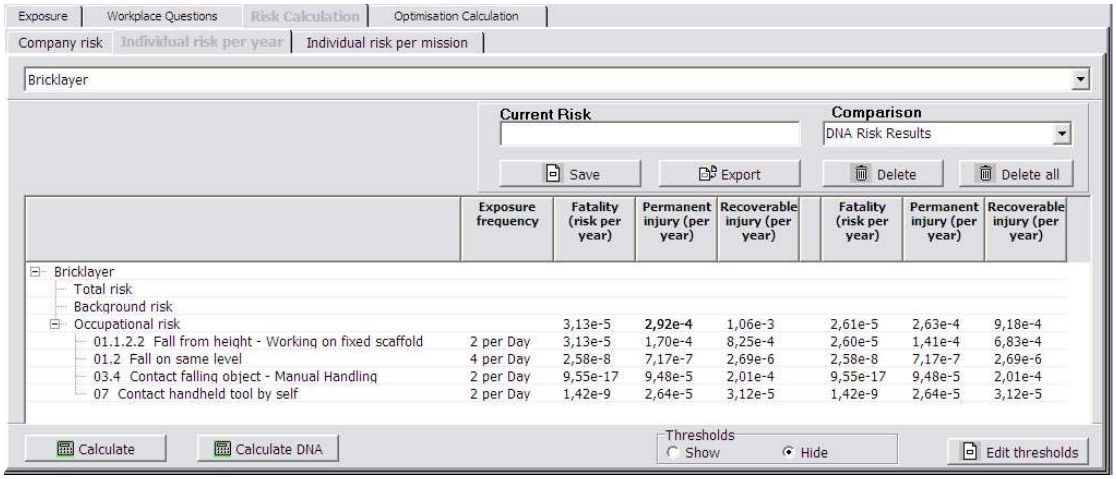
Editing the thresholds to suit your particular ideas is done by clicking the 'edit thresholds' button. ORCA than presents you with a dialogue box. The image below shows the relation between the information you enter and the coloring of risks. Again, threshold numbers are only meant to serve as an example. *In essence, you enter a high and a low threshold for each risk.*



Screenshot 17 How thresholds determine the coloring of risks

'Individual risk per year'

This part of the risk calculation step presents more information on the risk individuals face for a specific job position. Again, we will use the position of bricklayer and the risk he faces to permanent injury to illustrate this. The total risk to permanent injury is, again, $2{,}92 \cdot 10^{-5}$ per year. This risk is the sum of the risks for all 4 hazards that the bricklayer faces (e.g. fall from height, fall on same level, contact falling object and contact handheld tool). In this case we did not use any background risk, therefore it does not show in this example.



Screenshot 18 The individual risk per year per job position

'Individual risk per mission'

Next, for each job position a 'risk per mission' is shown. The term mission refers back to the exposure step. Here, we assigned the time that the worker is exposed to several hazards. For the bricklayer, our main example, this exposure was:

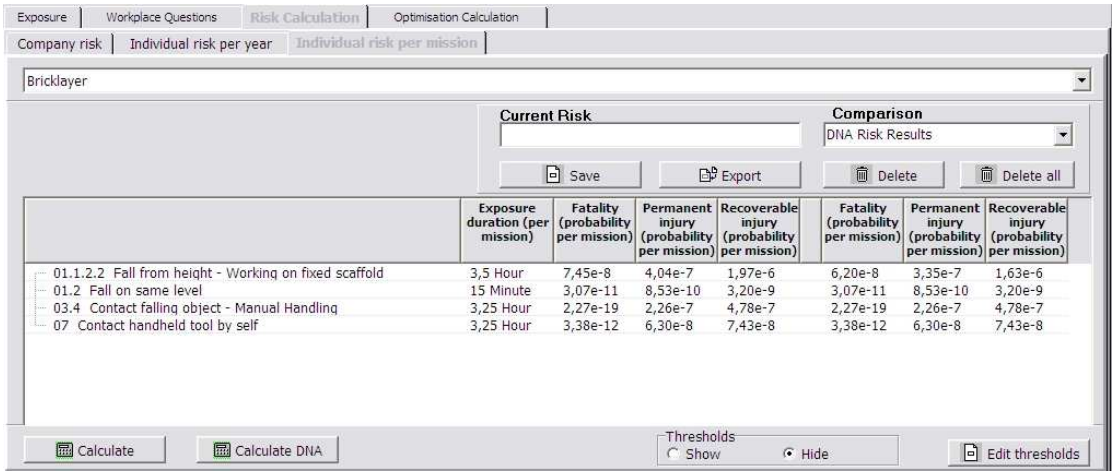
"After going up in the morning, our bricklayers work on scaffolds for 3,5 hours. Around noon they go down for a lunch break of about half an hour and then resume work for another 3,5 hours. Traveling time up and down the scaffolding is 15 minutes. Each morning and afternoon a 15 minute break on the scaffolding is taken"

Working context	:	Working on fixed scaffold
Hazard	:	Fall from height
Exposure	:	2 times per day, **3,5 hours each time/mission**.
Working context	:	Walking or standing
Hazard	:	Fall on same level
Exposure	:	4 times per day, **15 minutes each time/mission**.
Working context	:	(Being near) manual handling or transport of loads
Hazard	:	Contact falling object
Exposure	:	2 times per day, **3,25 hours each time/mission**.

Working context : Working with handheld tool
Hazard : Contact handheld tool by self
Exposure : 2 times per day, **3,25 hours each time/mission**.

The exposures (shown in bold) are presented as 'missions' in Screenshot 19 with the risk that they pose to an individual bricklayer over the course of a year.

For example, our bricklayer has a yearly risk of $4{,}04 \cdot 10^{-7}$ for being permanently injured due to a fall from height when working on a fixed scaffold. Again this is a slightly higher risk than a bricklayer faces in an average Dutch company ($3{,}35 \cdot 10^{-7}$) because of the answers we gave to the PIE questions.

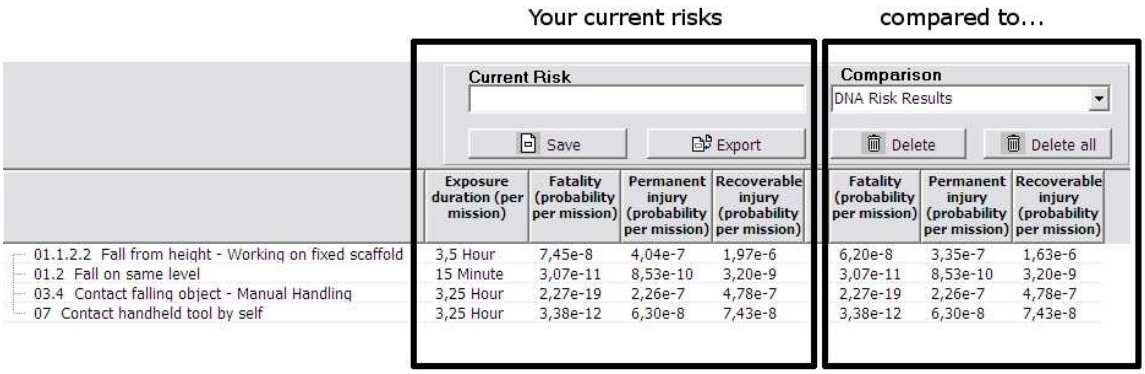

Exposure
Workplace Questions
Risk Calculation
Optimisation Calculation
Company risk
Individual risk per year
Individual risk per mission
Bricklayer
Current Risk
Comparison
DNA Risk Results
Save
Export
Delete
Delete all
Exposure duration (per mission)
Fatality (probability per mission)
Permanent injury (probability per mission)
Recoverable injury (probability per mission)
Fatality (probability per mission)
Permanent injury (probability per mission)
Recoverable injury (probability per mission)
01.1.2.2 Fall from height - Working on fixed scaffold 3,5 Hour 7,45e-8 4,04e-7 1,97e-6 6,20e-8 3,35e-7 1,63e-6
01.2 Fall on same level 15 Minute 3,07e-11 8,53e-10 3,20e-9 3,07e-11 8,53e-10 3,20e-9
03.4 Contact falling object - Manual Handling 3,25 Hour 2,27e-19 2,26e-7 4,78e-7 2,27e-19 2,26e-7 4,78e-7
07 Contact handheld tool by self 3,25 Hour 3,38e-12 6,30e-8 7,43e-8 3,38e-12 6,30e-8 7,43e-8
Calculate
Calculate DNA
Thresholds
Show
Hide
Edit thresholds

Screenshot 19 The individual risk per mission per job position

Comparing different results

In this manual we have only used the DNA to compare the risks of the example company to, but ORCA also has the possibility to make a comparison with previously saved risks. By clicking on the 'save' button and entering a name for this set of risks they are saved for later use.

After saving the set of risks it is accessible in the drop-down field under 'comparison', providing an easy way to quickly comparing your data.


Your current risks
compared to...
Current Risk
Comparison
DNA Risk Results
Save
Export
Delete
Delete all
Exposure duration (per mission)
Fatality (probability per mission)
Permanent injury (probability per mission)
Recoverable injury (probability per mission)
Fatality (probability per mission)
Permanent injury (probability per mission)
Recoverable injury (probability per mission)
01.1.2.2 Fall from height - Working on fixed scaffold 3,5 Hour 7,45e-8 4,04e-7 1,97e-6 6,20e-8 3,35e-7 1,63e-6
01.2 Fall on same level 15 Minute 3,07e-11 8,53e-10 3,20e-9 3,07e-11 8,53e-10 3,20e-9
03.4 Contact falling object - Manual Handling 3,25 Hour 2,27e-19 2,26e-7 4,78e-7 2,27e-19 2,26e-7 4,78e-7
07 Contact handheld tool by self 3,25 Hour 3,38e-12 6,30e-8 7,43e-8 3,38e-12 6,30e-8 7,43e-8

Screenshot 20 Comparing different results

Exporting your data

Next to the save button you will find the export-button. This feature will create a standard text file where the information is separated by a tab. This file can be easiliy imported into for example Microsoft Excel.

The information which is exported into this text file is:

Company Risk

Position in Company		Number of Workers	Fatality	Permanent Injury	Recoverable Injury
Bricklayer		60	3,13E-05	2,92E-04	1,06E-03
Forkliftdriver		15	1,88E-05	1,12E-04	1,82E-04
Inspector		3	1,49E-05	1,11E-04	4,58E-04
Total		78	2,21E-03	1,95E-02	6,77E-02

Individual Risk per Year

Position in Company		Frequency	Fatality	Permanent Injury	Recoverable Injury
Bricklayer					
	01.1.2.2 Fall from height - Working on fixed scaffold	2 per Day	3,13E-05	1,70E-04	8,25E-04
	01.2 Fall on same level	4 per Day	2,58E-08	7,17E-07	2,69E-06
	03.4 Contact falling object - Manual Handling	2 per Day	9,55E-17	9,48E-05	2,01E-04
	07 Contact handheld tool by self	2 per Day	1,42E-09	2,64E-05	3,12E-05
	Background Risk				
Forkliftdriver					
	03.2 Contact falling object - Mechanical Lifting	16 per Day	3,24E-06	4,34E-05	4,23E-05
	11 In or on moving vehicle with loss of control	32 per Day	1,56E-05	6,88E-05	1,39E-04
	Background Risk				
Inspector					
	01.1.2.2 Fall from height - Working on fixed scaffold	4 per Day	1,49E-05	8,03E-05	3,90E-04
	01.2 Fall on same level	8 per Day	5,16E-08	1,43E-06	5,38E-06
	03.4 Contact falling object - Manual Handling	12 per Day	2,94E-17	2,92E-05	6,18E-05
	Background Risk				

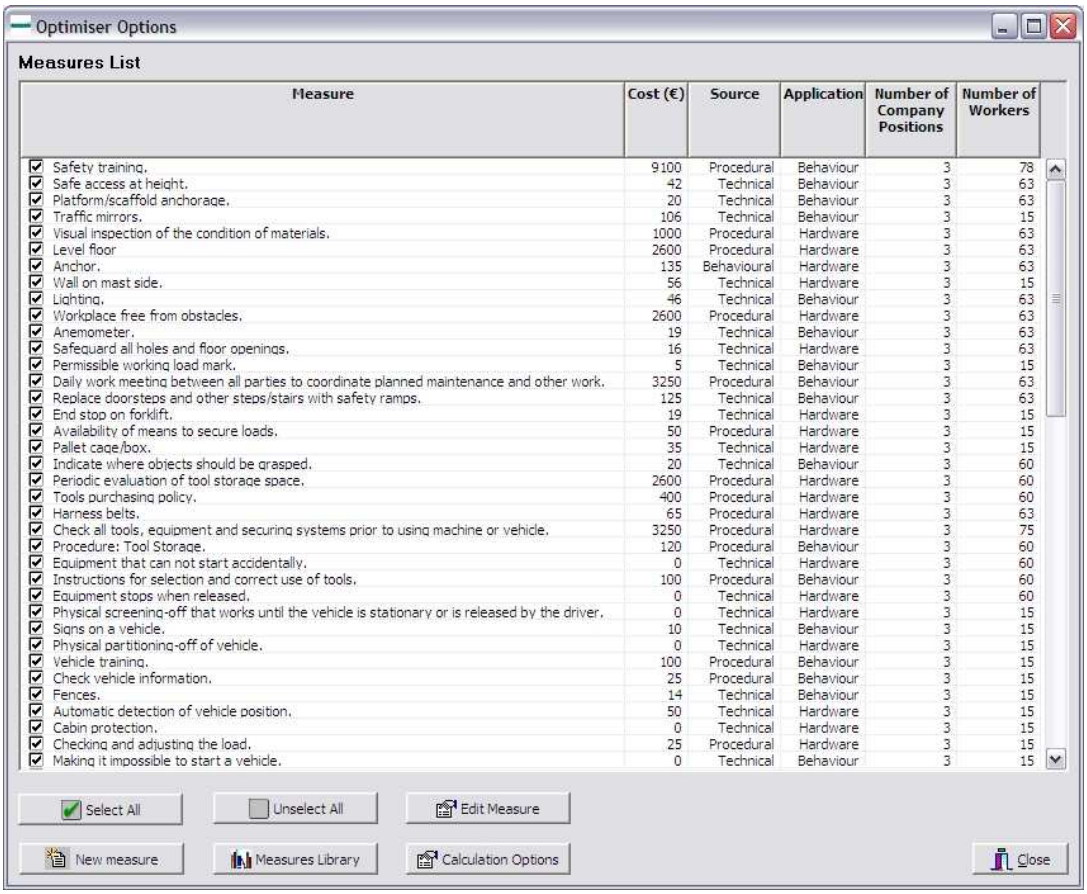
Individual Risk per Mission

Position in Company		Duration	Fatality	Permanent Injury	Recoverable Injury
Bricklayer					
	01.1.2.2 Fall from height - Working on fixed scaffold	3,5 Hour	7,45E-08	4,04E-07	1,97E-06
	01.2 Fall on same level	15 Minute	3,07E-11	8,53E-10	3,20E-09
	03.4 Contact falling object - Manual Handling	3,25 Hour	2,27E-19	2,26E-07	4,78E-07
	07 Contact handheld tool by self	3,25 Hour	3,38E-12	6,30E-08	7,43E-08
Forkliftdriver					
	03.2 Contact falling object - Mechanical Lifting	10 Minute	9,63E-10	1,29E-08	1,26E-08
	11 In or on moving vehicle with loss of control	10 Minute	2,31E-09	1,02E-08	2,07E-08
Inspector					
	01.1.2.2 Fall from height - Working on fixed scaffold	1 Hour	1,77E-08	9,57E-08	4,65E-07
	01.2 Fall on same level	15 Minute	3,07E-11	8,53E-10	3,20E-09
	03.4 Contact falling object - Manual Handling	10 Minute	1,17E-20	1,16E-08	2,45E-08

Screenshot 21 Example of data export to a text file

4. ‘OPTIMISATION CALCULATION’

The final step in ORCA, the optimisation process, needs some explanation regarding ‘measures’. The first tab called ‘run optimisation’ initially only has two buttons: ‘Optimiser options’ and ‘Optimise’. By clicking the button ‘optimiser options’ ORCA will show a list of relevant measures:

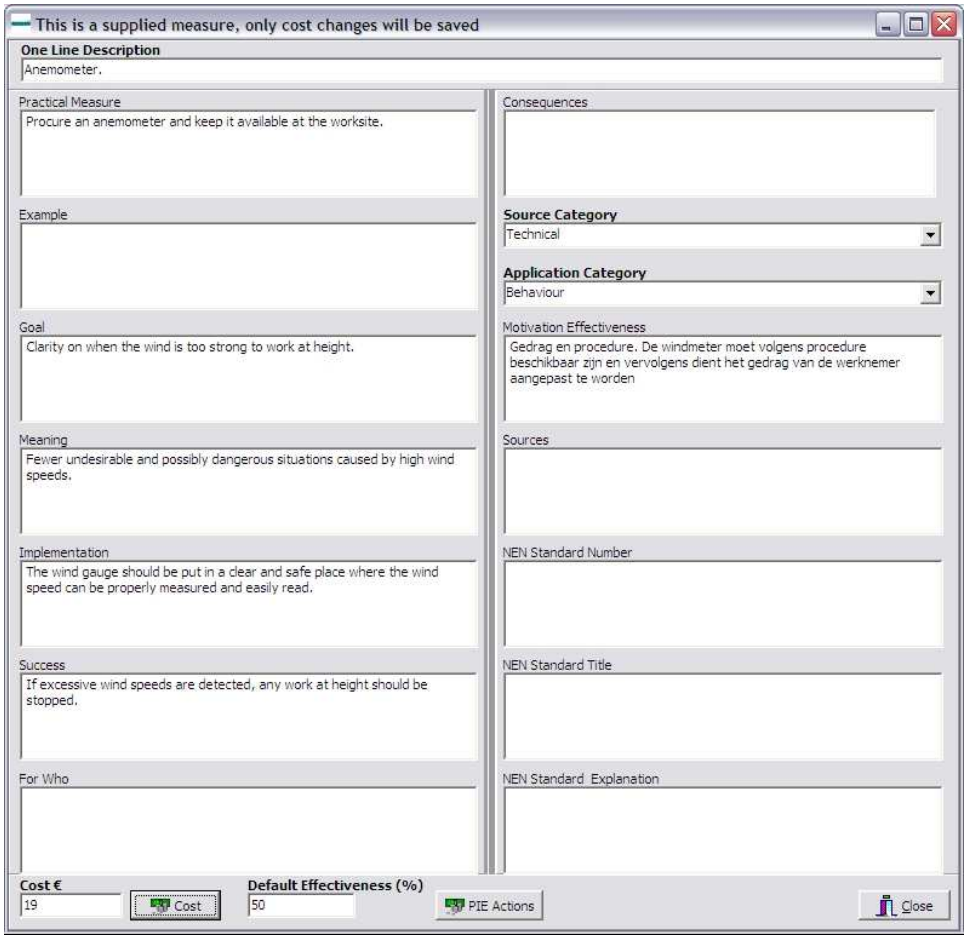

Optimiser Options
Measures List
Measure
Cost (€)
Source
Application
Number of Company Positions
Number of Workers
Safety training. 9100 Procedural Behaviour 3 78
Safe access at height. 42 Technical Behaviour 3 63
Platform/scaffold anchorage. 20 Technical Behaviour 3 63
Traffic mirrors. 106 Technical Behaviour 3 15
Visual inspection of the condition of materials. 1000 Procedural Hardware 3 63
Level floor 2600 Procedural Hardware 3 63
Anchor. 135 Behavioural Hardware 3 63
Wall on mast side. 56 Technical Hardware 3 15
Lighting. 46 Technical Behaviour 3 63
Workplace free from obstacles. 2600 Procedural Hardware 3 63
Anemometer. 19 Technical Behaviour 3 63
Safeguard all holes and floor openings. 16 Technical Hardware 3 63
Permissible working load mark. 5 Technical Behaviour 3 15
Daily work meeting between all parties to coordinate planned maintenance and other work. 3250 Procedural Behaviour 3 63
Replace doorsteps and other steps/stairs with safety ramps. 125 Technical Behaviour 3 63
End stop on forklift. 19 Technical Hardware 3 15
Availability of means to secure loads. 50 Procedural Hardware 3 15
Pallet cage/box. 35 Technical Hardware 3 15
Indicate where objects should be grasped. 20 Technical Behaviour 3 60
Periodic evaluation of tool storage space. 2600 Procedural Hardware 3 60
Tools purchasing policy. 400 Procedural Hardware 3 60
Harness belts. 65 Procedural Hardware 3 63
Check all tools, equipment and securing systems prior to using machine or vehicle. 3250 Procedural Hardware 3 75
Procedure: Tool Storage. 120 Procedural Behaviour 3 60
Equipment that can not start accidentally. 0 Technical Hardware 3 60
Instructions for selection and correct use of tools. 100 Procedural Behaviour 3 60
Equipment stops when released. 0 Technical Hardware 3 60
Physical screening-off that works until the vehicle is stationary or is released by the driver. 0 Technical Hardware 3 15
Signs on a vehicle. 10 Technical Behaviour 3 15
Physical partitioning-off of vehicle. 0 Technical Hardware 3 15
Vehicle training. 100 Procedural Behaviour 3 15
Check vehicle information. 25 Procedural Behaviour 3 15
Fences. 14 Technical Behaviour 3 15
Automatic detection of vehicle position. 50 Technical Hardware 3 15
Cabin protection. 0 Technical Hardware 3 15
Checking and adjusting the load. 25 Procedural Hardware 3 15
Making it impossible to start a vehicle. 0 Technical Behaviour 3 15
Select All
Unselect All
Edit Measure
New measure
Measures Library
Calculation Options
Close

Screenshot 22 List of measures used in the optimization process

Initially, ORCA selects all measures that can contribute to improving your company safety. By default, all measures are selected for use in the optimization process. Of coarse, it is possible to unselect specific measures. Unselecting specific measures is particularly useful if the company has these measures in place. For example, an anemometer (a tool for measuring wind force) is a standard piece of equipment in the work sites of our company. This equipment is useful because strong winds, when working on heights, can cause harm to an inspector or bricklayer (i.e. falling).

Before unselecting any measure, it is advised to closely look at what the measure actually consists of and decide on how closely the measure matches the situation at your company. There are generally three types of information available for any one measure: a detailed **description** (for example the goal, implementation, effectiveness of the measure), associated **costs** and the corresponding ‘**PIE actions’**. This information is accessed by clicking the ‘Edit Measure’ button.

Please note: the options ‘new measures”, “measure library” and “calculation options” are advanced options. They are not discussed at this moment.


This is a supplied measure, only cost changes will be saved
One Line Description
Anemometer.
Practical Measure
Procure an anemometer and keep it available at the worksite.
Consequences
Example
Source Category
Technical
Application Category
Behaviour
Goal
Clarity on when the wind is too strong to work at height.
Motivation Effectiveness
Gedrag en procedure. De windmeter moet volgens procedure beschikbaar zijn en vervolgens dient het gedrag van de werknemer aangepast te worden
Meaning
Fewer undesirable and possibly dangerous situations caused by high wind speeds.
Sources
Implementation
The wind gauge should be put in a clear and safe place where the wind speed can be properly measured and easily read.
NEN Standard Number
Success
If excessive wind speeds are detected, any work at height should be stopped.
NEN Standard Title
For Who
NEN Standard Explanation
Cost €
19
Cost
Default Effectiveness (%)
50
PIE Actions
Close

Screenshot 23 Example of a 'measure'

The measures in ORCA are supplied 'as is' and any changes made in the description fields and PIE actions are not saved. Costs however may be changed by the user because they can change over time or addition costs have to be made according to company specification. Clicking the ´Cost´ button reveals this information. The user can change information regarding the:

Hardware measure:

- number of purchases,
- cost to purchase.

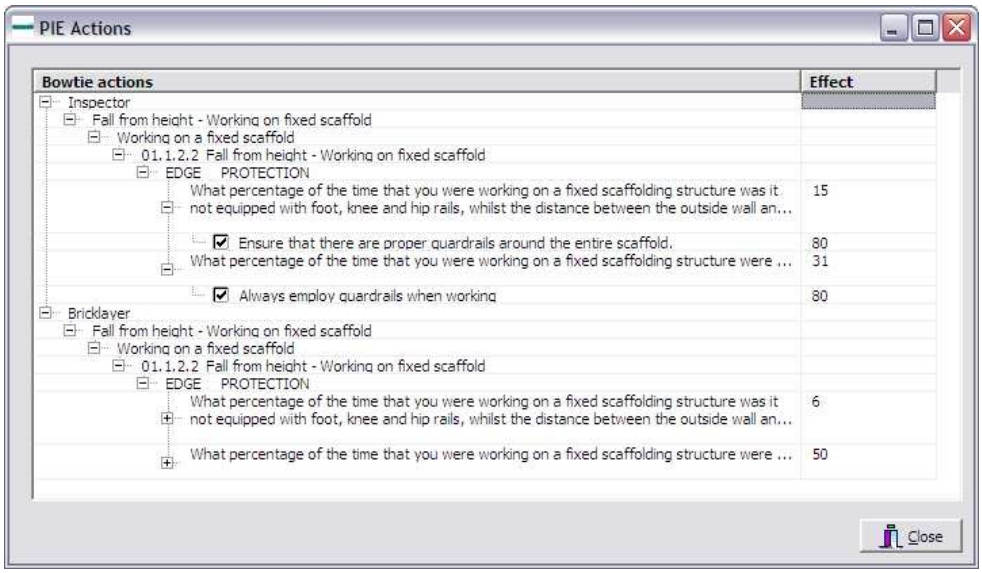
Time and costs for workmen, supervisors and managers to use the measure:

- number of hours to perform tasks,
- number for this task,
- hourly wage,
- yearly Frequency of Task.

Training people to effectively use the measure:

- number of persons training,
- daily costs of training,
- yearly frequency of training.

All information is then automatically added together and divided by the years the measure is expected to be in service (durability).


PIE Actions
Bowtie actions
Effect
Inspector
Fall from height - Working on fixed scaffold
Working on a fixed scaffold
01.1.2.2 Fall from height - Working on fixed scaffold
EDGE PROTECTION
What percentage of the time that you were working on a fixed scaffolding structure was it not equipped with foot, knee and hip rails, whilst the distance between the outside wall an...
15
Ensure that there are proper guardrails around the entire scaffold.
80
What percentage of the time that you were working on a fixed scaffolding structure were ...
31
Always employ guardrails when working
80
Bricklayer
Fall from height - Working on fixed scaffold
Working on a fixed scaffold
01.1.2.2 Fall from height - Working on fixed scaffold
EDGE PROTECTION
What percentage of the time that you were working on a fixed scaffolding structure was it not equipped with foot, knee and hip rails, whilst the distance between the outside wall an...
6
What percentage of the time that you were working on a fixed scaffolding structure were ...
50
Close

Screenshot 24 PIE Actions for the measure 'guardrails'

Finally, the button ‘PIE actions’ will present a pop-up with information on how this measure influences safety. The example above shows the PIE actions for another measure besides the anemometer: guardrails. Let’s have a look at the job position of Bricklayer:

Hazard : *Fall from height – Working on fixed scaffold*
Working context : *Working on a fixed scaffold*
Corresponding bowtie : *01.1.2.2 Fall from height–Working on fixed scaffold*
Barrier in this bowtie : *EDGE PROTECTION*
The Workplace question : *“What percentage of the time that you were…”*

The answer to this workplace question should be familiar as they have been given in one of the previous steps. Often these answers will be the default DNA value but here, the last answer of 50% is not equal to the DNA because it has been changed by the user.

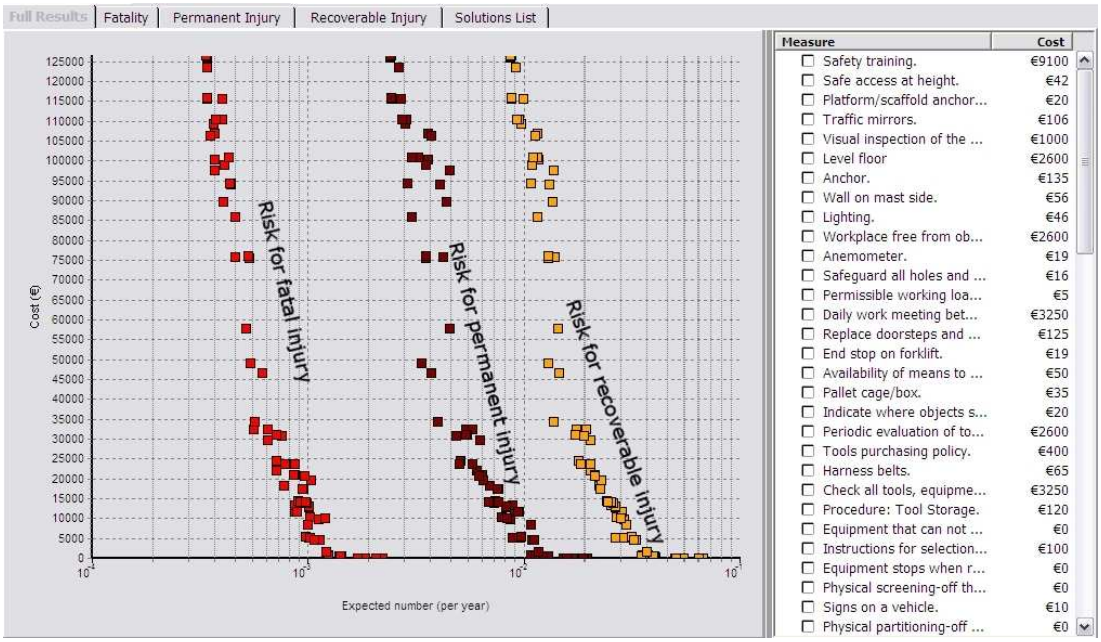
This information is particularly useful to get more insight in how different parts of the model influence each other. In this case how a measure influences safety or what barriers are influenced (improved) by what measures.

Note: Appendix 2 may help understand how barriers, PIE actions and measures are interrelated.

´Optimisation results´

Now that we have given ORCA all the necessary information it requires, it is time for the optimization step. In this step ORCA will try out many different combinations of measures and calculate their combined effect on company risks. Please note that this optimization step will take some time, all depending on the capacity of your computers system.

The result is a graph presenting the many possible solutions. A solution is defined as a combination of one or more measures. The first screen will show all three types of risks: fatal (color red), permanent (color brown) and recoverable injury (color yellow). These risks can also be shown individually by clicking on the corresponding tab.



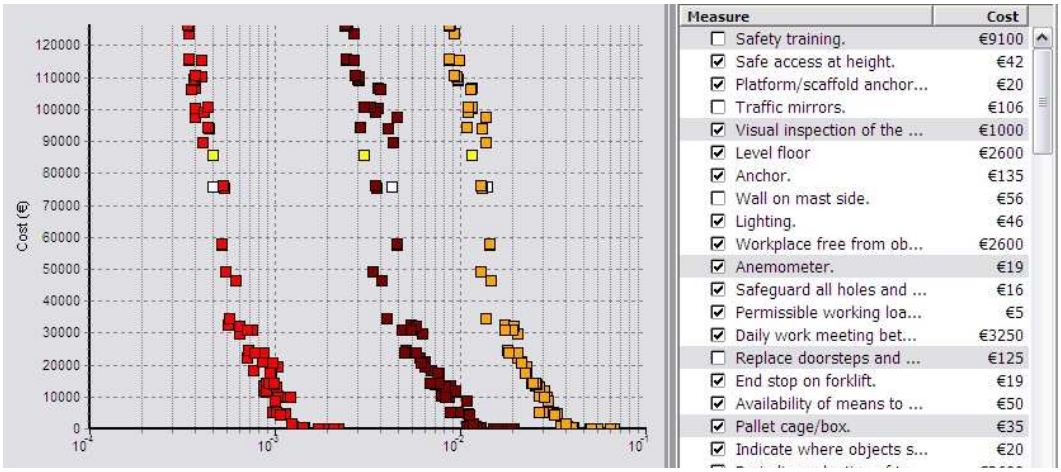
Screenshot 25 Full results for solutions after the optimization process

The image above shows the results produced by ORCA. As said, each square represents a set of measures and is plotted in a graph according to the estimated cost for implementing the measures and for the expected new company risk (or number or occupational casualties per year).

Comparing solutions

After clicking on a square (=solution), ORCA will show the associated measures in the right-hand list. This is a nice feature but ORCA also lets you compare two different sets of measures, two solutions. Comparing solutions is a little tricky and requires some practice. This is how is works:

- Clicking on a solution (box) will show the associated measures (check-boxes are checked). The square will turn white for all three risk types.
- Clicking on a second solution will turn the first solution into yellow and the second solution will turn white.
- The measures associated with the white solutions are checked.
- The measures associated with the yellow solutions are shown on a grey shaded background.



Screenshot 26 Comparing two different solutions

Zoom and drag function
Using the zoom function also requires some persistence to master and is not quite as intuitive as it could be. Here is how the zoom function works:

- Dragging a box with the left mouse button from left-to-right enables a user to zoom-in

- Dragging a box from right-to-left will show the entire graph.

When you are zoomed in on several solutions, the user can *drag the screen by holding the right mouse button*.

Note: dragging when 'Logarithmic Risk Axis ' is checked may result in losing focus of your position. Dragging is best used in a non-logarithmic scale.

Solution list
The 'solution list' tab is a complete overview of the measures that make up the solutions. Risks can be shown in **absolute risks** or in they can show the percentage they improve the risk for fatal, permanent and recoverable injury, compared to the original risk.

				Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
					Saf	Saf	Plat	Tra	Visu	Lev	Anc	Wal	Ligh	Wo	Ane	Saf	Per	Dail	Rep	End	Ava	Pall	Indi
Solution	Cost (€)	Fatality	Permanent	Recoverab	€91	€42	€20	€10	€10	€26	€13	€56	€46	€26	€19	€16	€5	€32	€12	€19	€50	€35	€20
22	€603	44%	38%	47%																		X	
23	€5056	55%	51%	57%																		X	
24	€13495	61%	55%	63%																		X	
25	€587	36%	37%	41%																		X	
26	€5355	56%	51%	54%																		X	
27	€10276	54%	60%	60%																X		X	X
28	€14436	59%	62%	64%																X		X	X
29	€4707	49%	44%	51%															X				
30	€11720	60%	52%	58%									X										
31	€5261	54%	55%	61%								X										X	
32	€675	44%	42%	48%								X										X	

Screenshot 27 Solution list, showing percentage improvement

				Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
					Saf	Saf	Plat	Tra	Visu	Lev	Anc	Wal	Ligh	Wo	Ane	Saf	Per	Dail	Rep	End	Ava	Pall	Indi	Per
Solution	Cost (€)	Fatality	Permanent	Recoverab	€91	€42	€20	€10	€10	€26	€13	€56	€46	€26	€19	€16	€5	€32	€12	€19	€50	€35	€20	€26
22	€603	1.23e-3	1.20e-2	3.59e-2																		X		
23	€5056	1.00e-3	9.62e-3	2.90e-2																		X		
24	€13495	8.69e-4	8.84e-3	2.53e-2																		X		
25	€587	1.41e-3	1.22e-2	3.99e-2																		X		
26	€5355	9.74e-4	9.64e-3	3.14e-2																		X		
27	€10276	1.02e-3	7.90e-3	2.67e-2																X		X	X	
28	€14436	8.98e-4	7.32e-3	2.41e-2																X		X	X	
29	€4707	1.13e-3	1.09e-2	3.31e-2															X					
30	€11720	8.91e-4	9.42e-3	2.84e-2									X											
31	€5261	1.01e-3	8.80e-3	2.66e-2								X										X		
32	€675	1.25e-3	1.12e-2	3.49e-2								X										X		

Screenshot 28 Solution list, showing absolute risks

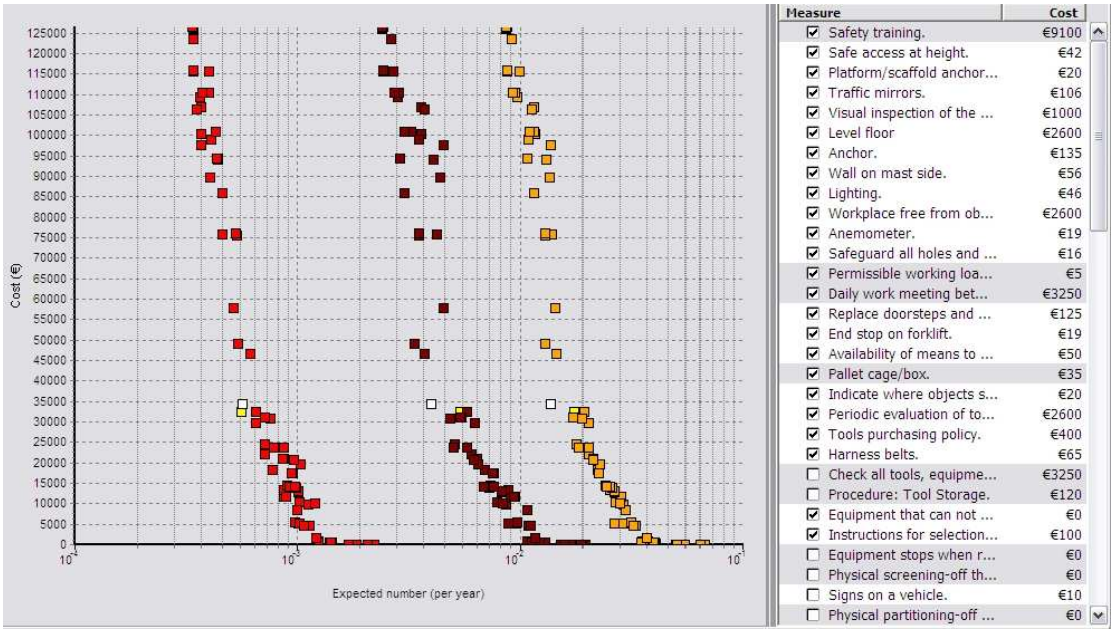
This table can be very, very large. Therefore ORCA lets you export these results into a text file for easy use in, for example, Microsoft Excel.

5. CHOOSING A SOLUTION TO IMPLEMENT

The process of choosing a solution which is to be implemented is different for each and every company. The choice is determined by many factors like costs and feasibility. But there is a rule-of-thumb which can be used to interpret the many solutions presented by ORCA. When we look at the red, brown and yellow solutions, we see that at some point costs show a strong rise while risk reduction is getting smaller. In other words, at some point reducing risks will get more and more costly. Each company has to make it's own choice on what amount of buget they wish to invest to improve safety.

Once a region has been identified, specific solutions can be compared. How this works was discussed in the previous chapter. In the screenshot below we see two solutions that are selected for comparing: the white and (bright) yellow solutions. The list of measures shows the corresponding measures (measures for the white solution are checked, measures for the bright yellow solution are shaded).

Besides looking into the measures for each solution we can also look at the expected improvement for the three injury classes (fatal, permanent and recoverable injury). As we can see, the two solutions score equally for reduction of the risk for fatal injury. But the first (white) solution scores better for permanent and recoverable injury.


Cost (€)
Expected number (per year)
Measure
Cost
Safety training. €9100
Safe access at height. €42
Platform/scaffold anchor... €20
Traffic mirrors. €106
Visual inspection of the ... €1000
Level floor €2600
Anchor. €135
Wall on mast side. €56
Lighting. €46
Workplace free from ob... €2600
Anemometer. €19
Safeguard all holes and ... €16
Permissible working loa... €5
Daily work meeting bet... €3250
Replace doorsteps and ... €125
End stop on forklift. €19
Availability of means to ... €50
Pallet cage/box. €35
Indicate where objects s... €20
Periodic evaluation of to... €2600
Tools purchasing policy. €400
Harness belts. €65
Check all tools, equipme... €3250
Procedure: Tool Storage. €120
Equipment that can not ... €0
Instructions for selection... €100
Equipment stops when r... €0
Physical screening-off th... €0
Signs on a vehicle. €10
Physical partitioning-off ... €0

Screenshot 29 Comparing and choosing a solution

If you wish to look into the solutions with even greater, ORCA offers you the possibility to export the data to a text file that can be easily imported into Microsoft Excel. Using the functionality of Excel, it is not hard to sort the data, for example by cost, risk for fatal, permanent or recoverable injury. Lets presume we implement the measures of first solution (the white square). Looking at the solution list we see the improved company risk.

	Fatality	Permanent	Recoverable
Initial company risk	$2.21 \cdot 10^{-3}$	$1.95 \cdot 10^{-2}$	$6.77 \cdot 10^{-2}$
Improved company risk	$5.63 \cdot 10^{-4}$	$3.98 \cdot 10^{-3}$	$1.37 \cdot 10^{-2}$

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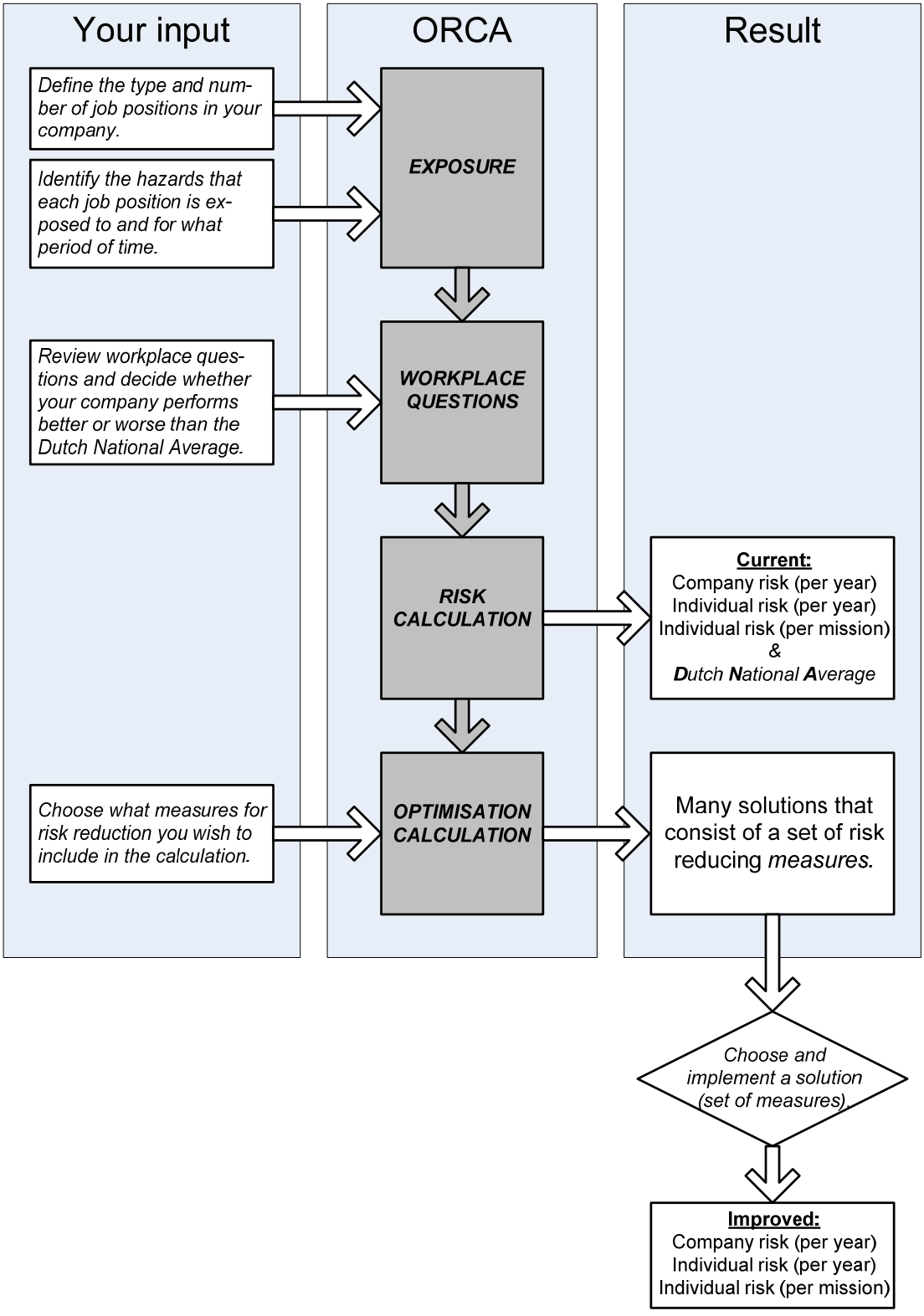
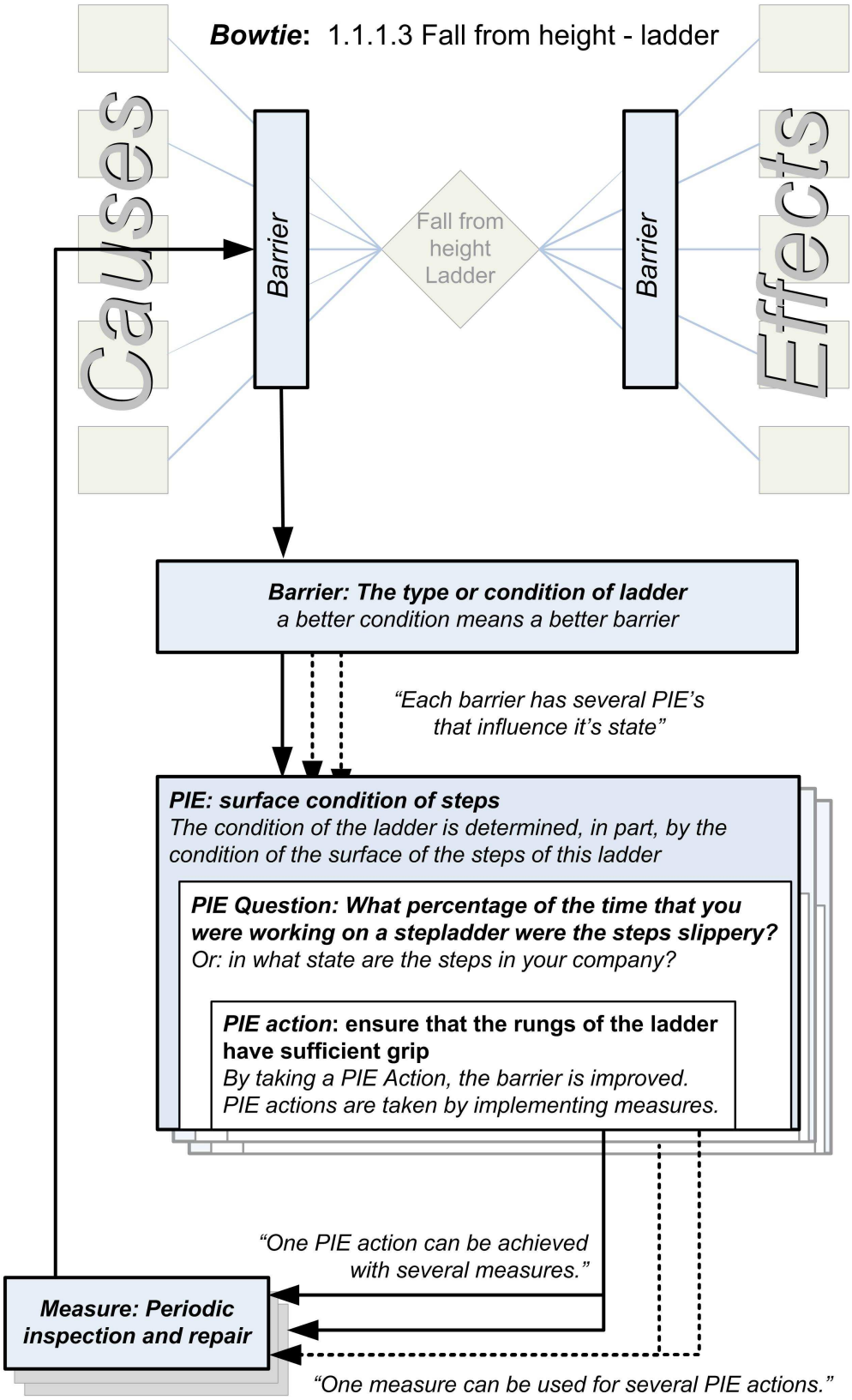
APPENDIX 1. THE WORKFLOW DIAGRAM


Your input
ORCA
Result
Define the type and number of job positions in your company.
Identify the hazards that each job position is exposed to and for what period of time.
EXPOSURE
Review workplace questions and decide whether your company performs better or worse than the Dutch National Average.
WORKPLACE QUESTIONS
RISK CALCULATION
Current:
Company risk (per year)
Individual risk (per year)
Individual risk (per mission)
&
Dutch National Average
Choose what measures for risk reduction you wish to include in the calculation.
OPTIMISATION CALCULATION
Many solutions that consist of a set of risk reducing measures.
Choose and implement a solution (set of measures).
Improved:
Company risk (per year)
Individual risk (per year)
Individual risk (per mission)

APPENDIX 2. BARRIERS, PIE'S AND MEASURES


Bowtie: 1.1.1.3 Fall from height - ladder
Causes
Barrier
Fall from height Ladder
Barrier
Effects
Barrier: The type or condition of ladder
a better condition means a better barrier
"Each barrier has several PIE's that influence it's state"
PIE: surface condition of steps
The condition of the ladder is determined, in part, by the condition of the surface of the steps of this ladder
PIE Question: What percentage of the time that you were working on a stepladder were the steps slippery?
Or: in what state are the steps in your company?
PIE action: ensure that the rungs of the ladder have sufficient grip
By taking a PIE Action, the barrier is improved.
PIE actions are taken by implementing measures.
"One PIE action can be achieved with several measures."
Measure: Periodic inspection and repair
"One measure can be used for several PIE actions."

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